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YELLOW FEVER IN WEST AFRICA

BY

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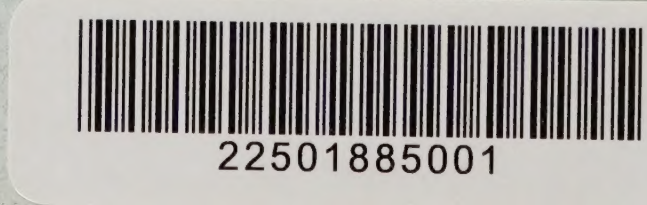

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YELLOW FEVER IN WEST AFRICA[1,2]

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Those of the present generation living in the Western Hemisphere have had little opportunity of gaining personal knowledge through direct contact with yellow fever. This was not true a few years ago when endemic and epidemic yellow fever occupied so many islands in the West Indies, the shores of the Gulf of Mexico and all of the countries of South America lying north of Santos on the Atlantic and Valparaiso on the Pacific. At the beginning of the present century, the problem relating to epidemic yellow fever in the tropical and subtropical regions of North and South America was a very acute one and demanded the attention of sanitarians, quarantine officers and investigators to bring the spread of the disease under control and to reduce the morbidity in the endemic regions. The demands of the problem were met through the brilliant work of the Yellow Fever Commission headed by Major Walter Reed and followed up by the practical sanitation applied through General Gorgas. There is no greater example of the brilliant success in the study of a devastating plague than that illustrated in the history of the control of yellow fever in America. Major Reed and his associates, Carroll, Lazear and Agramonte, in 1900, by means of carefully planned experiments, were able to offer proof of the conveyance of the virus of yellow fever by means of the stegomyia mosquito within a period of six months after beginning the work. Their studies were based upon the unproved observations of Carlos Finlay who believed that the propagation of yellow fever was solely attained through the agency of the mosquito. His own experiments had failed to prove his contention, though he still clung to his belief. But the experiments upon humans which were undertaken by the Yellow Fever Commission were fully

[1] The observations on which this paper is based were conducted under the auspices of the International Health Division of the Rockefeller Foundation.

[2] December 6, 1927.

justified and through the care with which the experiments were planned, definite conclusions were reached incriminating a particular mosquito (*Aedes aegypti*) and demonstrating that the virus was present in the blood of the yellow fever patient during the first three days of his illness, during which period the mosquito obtained the infection while biting the patient and sucking blood. Furthermore, it was found that the mosquito was unable to transmit the virus to a new individual until an incubation period of twelve or more days had elapsed. During the period of time which elapses between the biting of the patient and the infection of a new non-immune individual, the virus is undergoing development in the body of the mosquito. It is still unknown to us whether the virus passes through some biological cycle, as is the case with the parasite of malaria, or whether it is merely increasing in numbers. However in experimental studies it has been shown that the virus of a yellow fever patient can be obtained in the blood and transferred directly to a new individual. But when the virus is obtained by the mosquito the twelve or more days of incubation must intervene before the mosquito can transmit the disease. This finding was in agreement with the observations of Carter, who in 1890 had noted that the development of the secondary cases following the outbreak of yellow fever at Orwood and Taylor in the Mississippi Valley, occurred at an interval of about fourteen days. The Yellow Fever Commission also found that the virus present in the circulating blood of the yellow fever patient is capable of passing through a Berkefeld filter and by them it is described as being ultramicroscopic. Other than indicating that the "*Bacillus icteroides*" of Sanarelli and the "*Bacillus x*" of Sternberg had no relation to yellow fever, the Reed Commission were unable to add anything further as to the actual nature of the infection in yellow fever.

However, the work that was accomplished by this Commission was of great value in indicating the way for the control of the disease. The proof that the stegomyia alone was responsible for its dissemination and the evidence that the fomites of a yellow fever patient bore no relation to the spread of the disease, clearly defined the method by which sanitary measures could be instituted and epidemics avoided.

Carter has most clearly defined the conditions which must be available for the propagation of the disease in endemic and epidemic form.

Firstly, there must be available a yellow fever patient in that stage of the disease in which the virus is circulating in the blood and from whom it may be conveyed to others by means of the mosquito. Secondly, there must be present a sufficient number of stegomyia in the vicinity of the patient to allow the chance contamination of the mosquitoes biting the unprotected patient and subsequent transference to other individuals; and thirdly, there must be available non-immune individuals to whom the infection may be conveyed. To create an endemic focus in any region presupposes a constant supply of the particular mosquito and an adequate number of non-immune individuals so that new generations of infection may be transferred from the sick to the well. The presence of an infected individual in a highly susceptible community in which large numbers of stegomyia are present will give rise to an intense epidemic unless the chain of events be broken by caring for one of the above three factors. Furthermore, it is evident that the development of an endemic center requires a sufficiently large population, where new non-immune individuals are constantly arriving or are being born so that the infection will not die out. Inasmuch as yellow fever leads to an immunity against subsequent attacks of the disease, an epidemic area may, for want of susceptible individuals, lead to a natural burning out of the epidemic. Examples of such temporary epidemics in which recurrence of the disease has made its appearance at intervals of time have taken place at New Orleans, Havana, Rio de Janeiro, Santos, and other large centers.

Although most of our information concerning yellow fever has been gained from the experience of the outbreaks in North and South America, the West Coast of Africa for more than one hundred years has shown itself to be an endemic area. Much discussion has centered about the question whether yellow fever had its origin in America or in Africa, but our historical data and medical records do not allow us to arrive at a final conclusion. Following upon the more extensive voyages which took place after Columbus discovered America, the migrating settlers, missionaries and military forces sought the shores of the Western Hemisphere in preference to the forbidding regions of the African tropics. Much better records are available concerning the conditions of the natives and the diseases prevalent amongst them

in the Western Hemisphere than from the occasional expeditions to the West Coast of Africa. Some claim that the associates of Columbus described an epidemic disease resembling yellow fever amongst the inhabitants of the West Indies and that yellow fever was present amongst the Maya people in Central America long before the white man ventured to cross the Atlantic. No reliance, however, can be placed upon these reports in which the details of the nature of the disease are not given. Furthermore, with the limited knowledge of the differentiation of plagues and pestilences at that time, there is every possibility that the descriptions may apply to other tropical diseases. Furthermore, as the slave trade began early in the sixteenth century, it is possible that in these early years transportation of the infection of yellow fever as well as other transmissible diseases may have taken place prior to the records now available. Slave trading, which increased materially through the seventeenth and eighteenth centuries, became an important factor in the further transportation of this disease to new centers where it had previously been unknown. The varied conditions of marine transportation which existed in those times, the sailing vessel with its ill-equipped accommodation, the water barrels filled at the last port of loading, filled with the ova and larvae of mosquitoes and breeding new generations through the whole of the lengthy voyage, and the crowding between decks in poorly ventilated spaces of large numbers of slaves reproduced the unsanitary conditions of these primitive people and allowed not only yellow fever but also other infectious diseases to break out in epidemic form and lead to great loss of life. Many a slave trader lost the entire income of his ill-gotten gains in the deaths amongst the incarcerated people who constituted his chief cargo. Not only was it possible for the slave ship travelling from Africa to the West Indies to convey the infection from East to West, but also on its return infected mosquitoes were readily transported from the West Indies to the East. Such conveyance has been amply demonstrated by the outbreak of yellow fever in England, France and Spain following upon the arrival of vessels from the West Indies.

The story of yellow fever is inseparably woven into the romance of the history of the settlement of the Western Hemisphere and into the life of the buccaneer of the Spanish Main. Through the means of

the awkwardly equipped sailing vessels used for the transportation of merchandise and colonists, carrying casks and freight upon the open decks, with their dark and sheltered compartments, mosquitoes were transported from port to port bearing with them diseases acquired at previous points of sailing. Thus from time to time new foci of infection were implanted from one island to another, and to the ports on the mainland. An endless succession of epidemic yellow fever visited district after district so that our neighbouring subtropical and tropical regions were constantly endangered by the revisitation of epidemic yellow fever. Through a study of the stegomyia we are now familiar with the ease with which this mosquito enters both passenger and freight vessels which are in port and particularly when the ships are close to land. The adult mosquito easily survives six weeks or longer and may not alone transmit its infection to the crew of the invaded vessel but again on migrating to the shores of the next port of call may infect the people of the new district and give the opportunity for an epidemic. Whether the stegomyia were distributed upon all of the islands of the West Indies and the shores of continental America prior to their transportation by the vessels of the invading European, is not known. It is found however, that all of the countries in tropical America possess this mosquito where the climatic conditions are satisfactory for its breeding. Hence the propagation of the disease through these countries is readily accomplished if the virus through the presence of an infected human individual, is available for dissemination amongst the susceptible people. The virus of yellow fever though present throughout the life of an infected mosquito is not transmitted to its progeny. Furthermore there is no evidence that mosquitoes may acquire the infection from other adult insects dead or alive. Up to the present time we know of no reservoir of the infection in any animal save man. It has been suggested by some authors that the infection may also be carried by some of the domestic animals but proof of this contention is entirely wanting, while at the same time there is evidence to the contrary inasmuch as when an epidemic of yellow fever is brought under control by the segregation of the human infected cases no further cases arise which can be ascribed to other than a known human source. A point of interest however which will be commented upon later has been noted in some

of the studies on the coast of Africa. It is found, namely, that in carrying out experiments on yellow fever and during the search for a susceptible animal for the laboratory transmission of the disease, the monkeys resident in the endemic zone of the disease (Nigeria) were not susceptible to the virus contained within the human blood while in those imported from India, where to our knowledge yellow fever has never existed, a great susceptibility was found. This in itself is not proof of the development of an active immunity through the presence of the disease in the African monkey, but nevertheless offers a suggestion worthy of further study.

The control of yellow fever in the Western Hemisphere has been one of the outstanding accomplishments of the twentieth century. Within a period of twenty-five years the many scattered endemic and epidemic centers have been rid of the yellow fever plague so that tropical America no longer withholds the advance of modern civilization because of the presence of this infection. The success of the measures which have made it possible to suppress yellow fever is dependent primarily upon the demonstration by Reed, Carroll and their associates, of the necessity of the insect vector to transmit the disease. The practical application of their findings was demonstrated by Gorgas shortly after the incrimination of the stegomyia and he was able to free Havana and Cuba of the presence of yellow fever, a disease which had continuously led to great loss of life upon this island for more than one hundred and fifty years. During the military occupation of Cuba from 1898 to 1902 General Gorgas served as Officer of Health and Sanitation of Havana. This city had acquired an evil reputation for recurrent outbreaks of yellow fever and as a focus from which the disease was transported to other islands in the West Indies and to the neighbouring American seaports. The attack upon yellow fever at Havana was made from two angles; firstly by the protection of the yellow fever patient from contact with the stegomyia thus preventing fresh mosquitoes conveying the infection to others, and secondly by the reduction of the number of stegomyia within the vicinity of the centers of population by destroying the breeding places about the houses. Other complementary sanitary measures were also carried out. That these measures were the effective cause of the eradication of yellow fever from this district was further proved when in 1904

General Gorgas by applying the same regulations in the Panama Canal Zone was able to free it from yellow fever in less than two years. A similar crusade carried out by General Gorgas and Dr. M. E. Connor in Guayaquil and by Oswaldo Cruz in Rio de Janeiro added further proof of the efficacy of these measures. In recent years Mexico, San Salvador, Peru, Columbia, and British Honduras have been able to eliminate this ancient pest so that today no epidemic yellow fever exists in America and only a few sporadic cases have been reported from the hinterland of Brazil.

Let us now turn our attention to the conditions as they exist in Africa. It is of interest to note that yellow fever has been more or less continuously present upon the West Coast of Africa since 1778, there being only an occasional year during this period of one hundred and fifty years, when the records in the British or French reports fail to comment upon it. How much earlier the disease existed amongst the native tribes we are unable to say, and lack of information concerning all types of epidemic diseases upon these rarely visited shores, leaves us in the dark as to the origin, spread and recurrence of yellow fever amongst the aboriginals of the dark continent. Of one feature however there is good evidence; yellow fever remained confined to the West Coast of the African continent extending from Senegal in the north to the Cameroons in the south. True it is that imported cases made their appearance to the north and south of this zone, but neither progressive epidemics nor endemic disease gained a foothold beyond these regions. Furthermore yellow fever did not invade central Africa, nor did it cross the height of land to make its appearance upon the east coast. The yellow fever zone today is very similar to that which existed a century ago, involving the coastal territories of Senegal, Gambia, Portuguese and French Guinea, Sierra Leone, Liberia, Ivory Coast, Gold Coast, Dahomey and Nigeria. Each of these districts is a potential menace, and though the disease may be quiescent and unrecognized for one or more years in any one of them, careful search will reveal its presence to a degree so that we are justified in speaking of the entire area as an endemic zone. The difficulty of clinically recognizing yellow fever in the African native allows many cases to be overlooked. Moreover it is a fact that the native of these regions possesses an immunity much

greater than the newly arrived white, and hence in the presence of the endemic type of the disease amongst the natives in whom the mortality is no greater than from 8 to 12 per cent, no particular attention is given to the matter. It is only when the same disease attacks the white with a mortality of 60 per cent and higher that the alarm is raised, and the event made a matter of record. Hence when Sir Rubert Boyce attempted to estimate the loss of life and the endemicity of yellow fever upon the West Coast of Africa, he was confronted by hopelessly inadequate records upon which to base such a survey. He states that when the fragmentary history of yellow fever in West Africa is examined, we will come to the conclusion that yellow fever was in all probability a disease endemial to the native races of this coast.

The early expeditions which brought home the reports of the deadly African fever of the coast, refer to it as "Yellow Jack," "Bulam fever," "fever of Fernando Po," "fever of the Bight of Benin," "Lagos fever," and other terms referable to the districts in which the disease was encountered. Too few of the new-comers were sufficiently versatile as to the characters of tropical diseases and no attempt was made to differentiate the various plagues and fevers so prevalent in tropical Africa. The slave ship which landed at these shores was a potent factor in distributing not only yellow fever, malaria, plague, relapsing fever, sleeping sickness and other endemial diseases, but was also involved in distributing the insect carriers of each of these diseases,—an event of much greater importance. The conditions on board the slave ship gave every opportunity for the carriage and breeding of various insect vectors, and particularly the stegomyia. Undoubtedly the water brought on deck from the fresh water supplies in Africa was infected with ova and larvae of this and other mosquitoes, and no doubt also many infected and uninfected adult mosquitoes were brought to the ship as she was receiving her load at the Coast.

It is well to have in mind the character of this coastal region as it exists today. In many respects tropical Africa on the West Coast bears many similarities to isothermic districts in South America; but from the standpoint of endemic and epidemic disease, these regions are widely different. In West Africa endemic yellow fever has been confined to the littoral districts between twenty degrees north latitude

and the equator. This infected strand varies in width from sometimes being only marginal and along the sea, to at other times extending as a wide zone two hundred or three hundred miles inland. This zone is not equally populated, and the tribes, though black, are quite distinct both in their physical characters, their customs and their community life. Little is known regarding the varying susceptibility of these tribes although it has been claimed that certain groups, as for example the Kroo-boys, are less susceptible to yellow fever than some of the neighbouring tribes. Along this entire coast, having an extent close to two thousand miles, the distribution has been very unequal and the epidemics have occurred in widely scattered areas in succeeding years. The most persistently infected region, in which no difficulty presents itself to demonstrate the recurrence of yellow fever year after year, lies along the Gulf of Guinea, and in particular affecting Nigeria, Dahomey and the Gold Coast. Next in importance at the present time appears to be Senegal.

The population of the yellow fever zone numbers upwards of forty million people. Nigeria alone has a population of nearly twenty million, of which only about four thousand are white. This colony, about three times the size of the British Isles has its densest population aggregated in the coastal portion, and is dotted with cities, towns and villages in almost countless numbers. The jungle country which recedes from the sea in a gradual elevation is closely seeded with tribal communities which intercommunicate by an intricate system of paths and highways. Hamlets, villages and towns follow each other in endless succession as one travels these communicating lines, and one is astonished to encounter large cities bounded by the unbroken jungle. Ibadan is the largest of these cities, with a population of about a quarter of a million. But whether hamlet or city, the conditions prevailing within them are very similar. The houses are usually of sun-baked mud walls with thatched roofs. Doors serve for protection, ventilation and light, there being no windows. Dirt floors and one or two partitions complete the apartment. One or more families occupy the few rooms, and neither conveniences nor decorations garnish the interior. Reed mats thrown on the floor serve in place of beds, a coloured cotton sheet, a covering for cool nights. In the corner is a small clay fireplace,—used only occasionally, preference being given to out-of-door cooking.

These communities, although under the control of a chief, have neither sanitary orderliness nor care. The houses may be built in family clusters surrounded by a stockade, while several of such clusters may be grouped into a small community. But there is no order of arrangement. The houses are scattered at random with narrow alleyways separating them; streets there are none, except the government highways. The native people have no sanitary conveniences established in relation to the individual houses or the communities, and the usual water supply is obtained from creeks or shallow wells. The British government is establishing as rapidly as possible, water supplies to the larger cities, realizing that this is one of the most potent methods for the control of not a few tropical diseases. In a yellow fever campaign, these measures greatly decrease the difficulties of bringing the disease under control. A liberal water supply immediately does away with storage barrels and storage tanks within the houses,—the very menace of yellow fever communities in serving as the breeding ground for the stegomyia.

Southern Nigeria with its extensive forests and jungles, with its lagoons and mangrove swamps along the coast, with its enormous and miasmic delta of the Niger, is peopled by a primitive race of many tribes. These people are tucked away in the recesses of the jungle; they have been backward in their development, and through ages of internecine war they are suspicious, fearsome and wary. It is with difficulty that the white man gains their confidence, and it is too much to hope for their intelligent coöperation in any progressive measures. The natives within the limits of their own tribal territory travel extensively along the sheltered paths of jungle or plain, or in the presence of waterways use dug-out canoes. On market days, and every day is market day in some neighbouring village, the paths are pattered by long files of pedestrians who often travel fifteen, twenty or even thirty miles during the day.

I have dilated at some length upon the character of the native conditions in Southern Nigeria as these have a bearing upon the endemicity of yellow fever, as well as upon the epidemic spread at certain seasons. Furthermore, the conditions as present upon the West Coast are so totally different from the organized communities of North and South America, that the problem of control introduces difficulties heretofore

not encountered. The conditions as found in the Gold Coast and in Nigeria apply in a general way to the remaining part of the infected zone. The coastal towns which have developed as the commercial centers for the export of native products to foreign parts, are but little different, having a small white population which may or may not have established segregated districts for residence, but where nevertheless the whites come in intimate contact with the native people. In none of these centers is there a well established sanitary control, and the supervision of the native quarters is still inadequate for the seriousness of the situation. This applies not only in respect to yellow fever, but to all of the tropical diseases which are endemic to the region. During the past year yellow fever has made its appearance in the coast towns of Dakar, Monrovia, Sekondee, Accra, and Lagos, while another pest the bubonic plague has gained a foothold at Lagos and its environs.

Repeated commissions have visited the West Coast of Africa to study the yellow fever situation. Each has reported its findings and conclusions upon the endemicity of the disease, the extent of the territory involved, the menace which uncontrolled epidemics present to foreign lands through the agency of commercial highways on land and sea, and the enormity of the problem of instituting satisfactory control measures to suppress the infection. In 1910, Sir Rubert Boyce, whose experience with the yellow fever epidemic in New Orleans in 1905 and subsequently in British Honduras (1905) and in the West Indies (1905) fitted him to carry out intensive studies of this disease, spent considerable time upon the West Coast to obtain more intimate information respecting the endemicity and the reasons for the continued propagation of this tropical plague amongst the natives. He collected extensive data upon the recurrence of yellow fever in each of the colonies scattered along the coast, and he presented irrefutable evidence that for more than a hundred years the coast had never been free from the infection. In each colony he was able to uncover annual records of varying numbers of cases so that an almost unbroken succession of years over the period of a century showed endemic and epidemic yellow fever. There were still those at home and abroad who denied the existence of yellow fever in Africa, claiming that the diagnosis had been confused with other tropical diseases.

It is true that the diagnosis of yellow fever in the native people of Africa offers many difficulties, and as Boyce points out, the available records rather than exaggerating the state of affairs on that continent, had much underrated its prevalence and seriousness. These records are contained in the reports of colonial medical officers, medical missionaries, ships' doctors and local traders. Furthermore, Boyce laid much stress upon the great variation in the severity of yellow fever as it occurred amongst the native. It was patent to all, and this was also true of the yellow fever epidemics in America, (e.g., Havana, Panama, and on the Amazon) that yellow fever in tropical countries where it had been endemic for many years, shows its epidemic and fulminant qualities with the advent of the "new-comer" or immigrant. Again and again the history of the small seaports on the West Coast records the wiping out of the handful of white settlers by yellow fever. This would occur in the absence of an epidemic amongst the natives; and this is still taking place today. It was found impossible to trace the source of the infection, and we do not wonder at the mystery which for so many years surrounded the outbreak of yellow fever. In recent years where the distribution of medical officers has given an opportunity to watch the morbidity from all causes amongst the native tribes, we repeatedly encounter small outbreaks of yellow fever in the white settlements without being able to determine the origin of the disease. No sick native can be found to account for the transfer to the white.

In truth it may be said, that in Africa, only the very severe and fatal cases of yellow fever amongst the coloured natives are diagnosed except under rare conditions of extensive epidemics such as were studied by Dr. Henry Beeuwkes and his associates during the past year at Asamenkase, Gold Coast. Boyce was so impressed by the infrequency of clinically recognizable yellow fever in the African negro, that he was forced to the conclusion that these people possess a fairly high acquired immunity. He is in agreement with Gorgas that no race possesses a natural immunity and there is evidence that people of all nationalities and races when exposed to yellow fever through the agency of the stegomyia will take the disease. In support of this the history of yellow fever in Panama shows the susceptibility of the Chinese and Hindus, who coming from a continent where yellow fever

had never existed, died by hundreds while employed by the French Canal Company during the eighties. And furthermore the evidence that the resistance of the African negro is not the result of a natural immunity, was shown when a force of some six hundred former slaves returned from America to Sierra Leone to fall prey to an epidemic of yellow fever. The losses in their ranks were much greater than the mortality amongst the indigenous natives. These West Indian negroes had been away from their plague-stricken African home for many years, and during this time they had escaped contact with the endemic disease. These facts and others indicate that the native people of the West Coast of Africa possess an acquired immunity to yellow fever which reduces the incidence of clinical yellow fever as well as the mortality. Boyce suggests that the young children are infected early in life, without however manifesting serious illness, and thus remain immune through adult-life. Only occasionally does the disease present itself in the native in a more severe form. However, the virus of the disease is available for transfer from both mild and severe cases. Thus the disease smolders in an unrecognizable form through many districts and its presence is not apparent until the arrival of non-immune immigrants from uninfected regions. This is very similar to the observations of Gorgas in both Cuba and Panama.

The publication of the reports by Boyce led to a considerable agitation and much controversy. Many were not ready to accept the statements as thus presented. However in 1913, the British government appointed a Yellow Fever Commission to investigate again the situation in West Africa. Sir James Kingston Fowler was chairman, and the Commission spent three years in collecting data. The Commission itself spent little time in personally investigating the disease or in assisting in the differential diagnosis or epidemiology of it, but concerned itself in reviewing the evidence of others who had reported the presence of yellow fever in Africa.

In the absence of any specific tests for the diagnosis of yellow fever, it is obvious that many clinical difficulties present themselves, and not a few cases are wrongly diagnosed. The usual criteria for the diagnosis has rested upon the sudden onset of fever, headache, prostration, epigastric tenderness, pain in back and vomiting followed by jaundice, black vomit, albuminuria, petechiae of skin, bleeding from gums or

nose, slow pulse, delirium, coma, and often death. These manifestations are not always present, certain ones being absent, and have their resemblance with the variation in the clinical picture of other tropical fevers. The milder cases particularly, showing only headache, fever, jaundice, and albuminuria may simulate malaria, relapsing fever, undulant fever, infectious jaundice, or even types of certain vegetable poisonings. We have encountered fatal cases of relapsing fever, malaria, plague, carbon tetrachloride poisoning and broncho-pneumonia in African natives in whom a diagnosis of yellow fever had been made during life. The autopsy followed by microscopic examination of the tissues and organs has proved the only satisfactory means of establishing a diagnosis.

Much discussion has centered about the relation of bilious remittent fever and yellow fever. Boyce believes that this is only a mild form of yellow fever and that one or more attacks of it, immunize the subject against yellow fever. Bilious remittent fever, he states also goes under the name of acclimatizing fever. However in the absence of proof, either by demonstrating the virus or by obtaining definite laboratory tests concerning its nature, it is not possible to offer any conclusions in this regard. The fact remains, that those who have been resident upon the West Coast for ten or more years, appear to possess a resistance not enjoyed by the new-comer. How this immunity is obtained by these occasional whites is far from clear. Do they pass through a mild form of the disease which we cannot recognize as yellow fever, but which resembles remittent fever? Boyce answers this in the affirmative. However, on the contrary, old timers do not necessarily carry an unusual protection, and every now and again one of them falls a victim to the disease. On the other hand the British Commission of 1913 "favour the view that in that portion of West Africa which extends from Senegal in the north to the French Congo in the south there are always some areas in which the infection is temporarily manifesting itself, and in this sense the West Coast is an endemic area. It is also probable that there are localities or areas in which the infection is more permanent or from which it is never wholly absent. This view is in opposition to that which regards yellow fever as a disease of almost universal prevalence."

Immediately at the conclusion of the Great War, General Gorgas

retired from the position of Surgeon-General of the American Army, and again involved himself in the interest of the study and eradication of yellow fever in all its haunts. Almost his entire life had been spent in fighting the "Yellow Jack" of commerce and the tropics. He had been associated with the International Health Board of the Rockefeller Foundation in its campaigns in Central and South America against yellow fever, and now in 1918, he planned the anti-stegomyia crusade in Guayaquil, Ecuador. In six months the work was complete and this city was changed from a pest-hole of disease, to one free from the tropical pestilences which had harassed it for two centuries. Gradually the situation in reference to yellow fever in America was improving to the degree that but few evidences of epidemic outbreaks occurred and the endemic foci had been reduced to one or two locations. Gorgas had entertained the idea and the hope that yellow fever could be banished completely from the earth. His success upon the American continent in completely eradicating the disease from one district after another, gave every prospect that the greater deed could be done. The African situation was not forgotten, and in 1920, under the auspices of the International Health Board, Gorgas headed a Commission to investigate the problem on the West Coast. He set out on his journey, but never reached his destination. While in England, he was seized with a paralytic stroke and died on July 3. Several of the members of the Commission had arrived in Africa and proceeded with their studies, but in the absence of the chief nothing of importance was accomplished. After a few months the Commission returned to America.

Again in 1926 the International Health Board organized another Commission under the leadership of Dr. Henry Beeuwkes to investigate the yellow fever situation in Africa. This Commission which is still actively at work has its headquarters near Lagos, Nigeria, and is coöperating with the British Government and its Colonial Officers both in Nigeria and the Gold Coast. Although it was hoped that after a preliminary survey of the distribution of the disease, the distribution of the stegomyia and the local conditions of the life of the native people, an intensive control campaign against yellow fever could be undertaken, it was found that many problems of the disease itself had to be cleared up. In the first place definite proof through

autopsy and pathological study had to be undertakn to fully establish the identity of the disease with that occurring in the Western Hemisphere. Furthermore, it had to be shown that the same vector, and it alone, was responsible for the conveyance of the disease from individual to individual. More data was necessary concerning the mosquitoes and their breeding. And finally it was essential to know more about the virus of the disease, whether the same organism as had been determined by Noguchi in South America was responsible for the yellow fever of Africa. In short, the Commission during its first year found itself at work upon an intensive research on West African yellow fever, in place of a sanitary crusade to suppress the disease.

It is of interest to note, that owing to the outbreak of a sharp epidemic of yellow fever in Senegal during the past two months of this year, the French government has been forced to take rigorous action for its suppression. A Commission of experts from Paris are now investigating the situation. The French daily press states that in the month of October more than two hundred deaths from yellow fever took place among whites alone in the zone about Dakar, while the Deputy of the district claims that the amount of yellow fever is not abnormal,—admitting that a certain amount of it was always with them. We thus have evidence, and this has been verified by us by pathological examination of the tissues of some of the fatal cases, that yellow fever is at present existing in Senegal, Gold Coast, Dahomey and Nigeria.

The Yellow Fever Commission of the International Health Board collected much valuable information during the past year (1926), while in the course of their intensive studies in the present year they have been able to uncover many new truths, the importance of which rank second only to the work of Reed and his group.

We have indicated the attitude of Sir Rubert Boyce to the question of the immunity of the black tribes of West Africa to yellow fever, he believing that these races have over centuries of time acquired a resistance by contact with the disease. He furthermore believed that almost universally the children of the people in the infected zone become infected and pass through a mild form of the disease in early childhood. This he claimed accounted for the absence of severe outbreaks of the disease amongst the natives, as well as the low

mortality amongst the infected. Several writers point out that no large epidemic of yellow fever has ever been reported among the African natives. Much of this appears to be true,—but closer examination shows it to be only in part true. The prevalence of yellow fever in the native tribes can only be learned by a close study and by living with them in their own districts. A survey of official records does not give the desired information nor can one rely upon the evidence of transient whites. Through the acuity of one of the district medical officers (Dr. J. Byrne) of the Gold Coast, Dr. A. M. Walcott of the Yellow Fever Commission was able to discover an extensive epidemic of yellow fever in the native town of Asamenkase in the interior, in which, it is estimated over one thousand natives became infected with a mortality of about 14 per cent. This epidemic, which is the largest on record on the West Coast, was carefully studied by Dr. Henry Beeuwkes and Dr. Walcott.

Such an epidemic would suggest that this group of people at least were not immune and had never had the disease in childhood or later. As this community was situated along the highway of native travel, it is difficult to conceive how it had escaped previous infection if the neighbouring villages and towns were constantly endemic centers. This would presuppose a chance escape from infection for several generations. On the other hand also, it was noted, that no progressive dissemination occurred into the outlying villages during or following the epidemic itself. The study of the situation proved that under certain conditions the native shows a susceptibility like that of the new-comer, with no evidence of an acquired or natural immunity, while at other times his resistance is decidedly higher than that of recent foreign arrivals.

I need not detail the clinical picture of the disease in these people, suffice to say that in the analysis of the symptoms by Dr. Beeuwkes, he found the manifestations to be similar to those observed in white people. However, it is of importance to recognize that the clinical picture of the disease occurring in West Africa and described by Barry, Ferguson, Lawson, Boyce and others is the same as that arising in North and South America, and as that given by Beeuwkes in the large epidemic in the Gold Coast. For purposes of record I shall recount some of the more important points stressed by Beeuwkes

(1926), who analyzed the case histories of 50 native patients. The ages of these patients ranged from childhood (5 cases) to over fifty years (2 cases), and there were more males (35 cases) attacked than females (15 cases). Two infants in arms were observed during the epidemic suffering from what seemed to be the same disease, but it was not possible to establish a conclusive diagnosis. The high incidence among children is better indicated in a survey of a neighbouring Mission School by Dr. Walcott who found that of 60 pupils subsequently returning to school, 30 claimed to have suffered the attack during the epidemic. The duration of the illness varied from four to nine days in the very mild cases, from five to twelve days in the moderately severe and from nine to fourteen days in the very severe (recovery) cases. The fatal cases died from the fourth day to the tenth day, and one case as late as the fifteenth day.

The temperature rises abruptly at the onset, quickly reaching 102° to 104°F. Remissions may appear on the second or third day, and again ascend to the original elevation or higher. In mild cases the temperature reached its normal in a few days, but in the severe cases the temperature persisted a week or more and more slowly returned to the normal level. The fatal cases commonly had a drop to subnormal, twelve or twenty-four hours before death. The pulse curve did not follow the temperature, there being frequently an initial rise to over 100 beats with a drop on the second or third day to 80 or less (at times as low as 40).

Headache was complained of by all of the fifty cases, and it usually was one of the first manifestations ushering in the illness. In a few only was its appearance delayed. The headache was usually frontal, in a few diffuse and in all it was persistent, lasting from two to four days or longer. This distress was accompanied by bodily pains and aches affecting the muscles of the limbs, the joints and the insertions of the muscle tendons. Pain in the back was stated to have been present as constantly as the headache, while the epigastric tenderness was common but more variable in its intensity appearing on the second to the fourth day. Photophobia and anorexia made their appearance at the onset, while prostration was noted in direct relation to the severity of the disease. Jaundice was demonstrable in all but ten mild cases, and varied from a deep colouration of the

sclerae and the floor of the mouth to a light tinge of yellow difficult to distinguish from the normal pigmentation present in the loose conjunctival membranes. Usually jaundice appeared about the third day, in some however its appearance was delayed as late as the tenth day. In the majority it persisted at least a week, in many for several weeks and at times continued long into convalescence. It is reported that not uncommonly individuals were seen walking about the streets with deeply jaundiced sclerae who on being questioned admitted having had an attack of this disease some weeks previously. The liver showed slight or considerable enlargement in 17 of 44 cases, while no case is recorded in which the liver was smaller than normal. The enlarged liver was usually tender to pressure. Of 44 cases examined all showed some enlargement of the spleen save sixteen. As, however, this is a very malarious district no weight can be appended to this finding.

Albuminuria was one of the striking features and constant occurrences of this disease, and was present in all the cases, usually beginning about the third day and progressively increasing up to death or until the onset of convalescence when its decline followed a curve the reverse of its development. The kidney functions appeared to be depressed in all their qualities and the quantitative output diminished as the disease progressed in severity. The disturbance of renal function is one of the serious conditions arising in the disease during its most critical phase. This progressive renal incompetence takes place at the same time when the liver function is most seriously impaired and the cardiac tissues are indicating distress from myocardial damage. Casts in increasing numbers accompany the albuminuria, and bile is present in the urine in those with marked icterus. Nausea and vomiting were usually present but not always. In one of the fatal cases no vomiting occurred. In some, vomiting appeared on the first day, in a larger number it began on the second or third day. Severe and continuous vomiting throughout the course of the illness was present in only a few cases. In 14 severe cases it was present from one to three days in 9 and from five to seven days in 4. It was noted that vomiting at the onset was more frequent in the mild than in the more severe cases. The vomitus varied in character, at times large in quantity, bile stained, and watery, later becoming grumous, blood stained or

"coffee-ground" type. It was found that in a number of the cases examined, there was a mild leucocytosis during the first day or two followed by a leucopenia.

Not only do the clinical characteristics of West African yellow fever coincide with the disease in the Americas, but also the gross and microscopical pathological findings. From the pathological study we arrive at the conclusion that yellow fever is an acute infectious disease whose outstanding lesions consist of fatty degenerations, necrobiosis and necrosis affecting in particular the liver, kidney, heart and spleen. Other organs and tissues also suffer but their influence upon the organism as a whole, is much less than that induced by the organs named. Yellow fever per se does not induce inflammatory processes, and in the cases which recover there is no scarring of the affected organs. Cirrhosis of the liver does not follow yellow fever, nor is a contracted kidney a sequel. The injury done is upon the parenchymatous tissues; stroma and vascular structures do not respond, and in the stage of repair the restitution is accomplished by a regeneration to replace the injured cells.

The injury to the liver is usually the most characteristic and serious lesion of the infecting agent. This organ suffers an intense destruction of the liver cells, beginning in the mid-zonal region as described by Rocha-Lima, and then extending into both the central and peripheral zones. This destructive process may progress to such a degree that very few liver cells remain. The few living liver cells are to be found close to the portal sheath on the outer edges of the lobule, and as a rim of scattered cells about the central vein. Otherwise the entire hepatic structure is in a state of necrobiosis and necrosis. But there is another point worthy of attention. The liver in yellow fever although suffering extensive necrobiosis and necrosis, is normal in size or even slightly enlarged. This is recognized in the gross specimen and on microscopic examination. The lobules are not collapsed or shrunken, and the individual cells though necrotic are often distended and enlarged. The necrotic liver cells do not appear readily to undergo autolysis. This resistance to disintegration may be in relation to the peculiar degenerative change which the liver cells suffer. In 1890 Councilman described the liver necrosis arising in yellow fever and pointed out that it was characterized by the de-

velopment of peculiar acidophilic hyaline globules within the cytoplasm of the cells. All who have studied the pathology of yellow fever have commented upon this product, and have noted that this hyaline material persists during all stages of disease (as available in human cases). These hyaline spherules vary in size and stain intensely with eosin and other acidophile stains. They have been mistaken for red blood corpuscles by the casual observer.

In this extensive liver necrosis the blood sinuses within the liver lobule are distorted but not obstructed. Thromboses and inflammation are absent, and the structures in the portal sheath are undisturbed. On the other hand a disturbance of the reticulo-endothelial system in the liver (Kupffer cells) is to be seen. This varies from a hyperplasia of these cells and a granular degeneration to an exfoliation and marked fatty degeneration with pigment accumulation. We have elsewhere pointed out that the influence of the virus and its toxins upon these cells accounts for the varying grade of jaundice which accompanies yellow fever. Jaundice is a variable sign and may be very misleading if one relies too strongly upon it in establishing a diagnosis.

Although the liver suffers so severely in this disease, and the toxins, if such they prove to be, appear to have such a selective action on the liver cells, it has not been possible up to the present time to demonstrate the presence of an organism in these tissues. Fatty degeneration is always present, occupying more intensely the cells in necrobiosis.

In the cases which recover, the regeneration of the liver parenchyma proceeds with great rapidity, and at the end of convalescence all the functions of the liver are restored to it. During the height of the attack, bile pigments are unable to pass through the liver lobule and little or none is emitted into the bowel; bile salts are wanting, and a state of hypoglycemia exists. The condition in the patient simulates an almost complete hepatectomy.

In one or two features the liver of the West African negro differs from that of the white European or American. It is noted that the liver in the adult African very commonly shows a grade of cirrhosis, of the biliary type. This fibrosis may be present as localized masses about the channels in the portal sheath, and may also show some extension into the neighbouring lobule. Sometimes it is slight, and visible only by aid of the microscope, but frequently too it is demon-

strable on the cut surface of the fresh liver. Besides this, the presence of a considerable collection of lymphocytes and some plasma cells is an almost universal finding in these natives. We have examined many livers obtained from individuals who have died of causes other than yellow fever or other diseases attacking the liver structures, and we have observed this lymphocytic reaction present in almost all of them. This may be the result of repeated and continued intestinal helminthiasis which is present in all as well as the presence of Bilharzia infection which is not uncommon. One other feature deserves notice. The colour of the liver in the Nigerian native possesses a tinge of orange yellow the result of the heavy consumption of crude palm oil. This article of diet causes a staining of the adipose tissues as well as of those organs which participate in fat metabolism.

A careful study of various portions of the liver show that all lobules are not equally affected. This irregularity in the intensity of the tissue attack, and the distribution within the liver is best seen in those cases where the lesions are not far advanced. Moreover we have been able to demonstrate in a number of cases that the left lobe of the liver may be less involved than the right, and may even escape serious injury while the yellow fever lesions are well marked in the lobules of the right lobe.

Next in importance to the lesions arising in the liver, are the damaging effects of the infection in the kidney. In disease importance the renal lesions stand close to those in the liver, and we believe that in a certain number of instances take precedence to them. In many respects the renal lesion bears a similarity to the hepatic one inasmuch as both are of the nature of a primary degenerative process of the parenchyma unaccompanied by inflammatory processes and in the cases which recover they leave behind no sequelae to incapacitate the function.

In the kidney the degenerative process may be observed varying from a simple cloudy swelling of the convoluted tubules of the cortex to a severe fatty degeneration and necrosis affecting not only the convoluted tubules of the first and second order, but also the limbs of Henle, and occasionally some of the tubules in the medulla. Commonly various grades of these degenerative changes may be observed in different portions of the same kidney. In the very severely affected

kidneys, and these are the ones in which an almost complete suppression of urine has been observed during life, the necrosis occupying the convoluted tubules is very extensive. The glomeruli are less affected showing congestion and some exfoliation of the surface epithelial cells. Granular and hyaline casts are distributed in considerable numbers through the various tubules of cortex and medulla. The presence of blood within the tubules is rarely seen, and haemorrhages from the glomeruli are very infrequent. Occasionally small interstitial haemorrhages are observed in the cortex. The fatty degeneration which affects the epithelial cells of the tubules of the cortex, varies considerably in its intensity.

Councilman drew attention to peculiar spherical hyaline bodies which were not uncommon in the lumina of the cortical tubules. These bodies, he pointed out, occurred in clusters, sometimes with a concentric lamination, at other times showing an almost crystaline radiating structure. These bodies stain darkly with haematoxylin, and in recent years Hoffmann has drawn attention to similar structures being impregnated with calcareous salts. Hoffmann has laid much stress upon the finding of the calcareous deposits commonly resembling those found in bichloride poisoning, and which he believes have a diagnostic value in the study of yellow fever tissues. We have observed these deposits in about 60 per cent of the fatal cases occurring in West Africa. Up to the present time it has not been possible to correlate the presence of these calcareous deposits with the clinical intensity of the disease, nor with any characteristic of the renal secretion.

The lesions in the heart are of the same order. A process of degeneration involves the myocardium while the valves and vessels are unaffected. The degenerative process is unaccompanied by inflammation, and affects the myocardium in all its parts including the auriculo-ventricular conducting system. Dilatation of the left ventricle is not uncommonly seen, and the muscular walls are soft and flabby as a result of the granular and fatty degenerative change. Here again all evidences of an inflammatory exudate are wanting. Clinically it has been noted that the pulse in yellow fever does not increase in proportion to the rise in temperature, and in fact may fall far below the normal level reaching as low a rate as forty. The

reason for this slow pulse is not clear. Some have suggested that it is the result of the jaundice and its associated conditions, others that it is related to the degenerative process affecting the conducting system. Further studies must be carried out upon these points, for our information is much too limited to offer a satisfactory interpretation.

Although the spleen is not materially enlarged during the course of a yellow fever attack, we have noted that it is not without reaction. Aside from the change in the size of the spleen due to an antecedent bout of malaria, this organ on macroscopic examination does not attract particular attention. On the cut surface the tissues may appear slightly congested, but there is no evidence of acute splenitis, and the malpighian bodies are small and indistinct. The microscopic examination reveals a marked reduction in the lymphocytic content of the follicles and a concurrent hyperplasia of the endothelial cells surrounding the malpighian bodies and in the pulp areas. This primary endothelial hyperplasia then gives way to degenerative changes in these cells, with necrosis of many of them. This reaction may have some significance in determining the nature and localization of the virus.

Thus it is evident that the quality and the distribution of the lesions arising in West African yellow fever are the same as that in America, and we are justified in the conclusion that they are one and the same disease.

Up to the present the virus of yellow fever in West Africa has not been determined, although the effort has been made by a number of investigators to isolate the *Leptospira icteroides* by the Noguchi technique. We also have failed to demonstrate this organism in the tissues of fatal cases, search having been made in all of the autopsy material by the use of the Levaditi method.

Many attempts were made to infect guinea pigs, puppy dogs, native brown monkeys, and some rodents with blood from yellow fever patients, but all of these trials gave negative results. The blood was obtained during the first few days of illness, and there was every reason to believe that the virus was present at this period. These experimental animals showed no evidence of illness, none died as the result of a transferred infection and their tissues showed no evidence of lesions. One was forced to the conclusion that these animals

possessed a natural immunity to yellow fever and that they were unsuitable for experimentation with yellow fever.

During the present year Dr. Adrian Stokes working in conjunction with Dr. J. H. Bauer under the direction of Dr. Henry Beeuwkes, undertook a new series of experiments using monkeys imported from India. The first series of inoculations were made into a number of Indian Crown monkeys and later similar inoculations of blood from yellow fever patients were made into *Macacus rhesus* monkeys. The reports upon these experiments have as yet not been made public, owing to the unfortunate death of Dr. Stokes, who himself fell a victim to the disease. His death occurred just at the time when it was proved that the *Macacus rhesus* was a suitable animal for experiments with yellow fever, that the animal passed through an incubation period followed by an illness simulating the disease in man, and that the gross and microscopic pathology of the tissues had all the earmarks of the characteristic lesions as have been described in man. These findings are a distinct step in the advance, and permit of carrying the yellow fever problem to the laboratory where the many details may be studied with greater intensity than is possible in the African jungle. Heretofore much of the work had to be carried on in the field and at remote stations amongst the whites and natives ill with the disease; now the work may be pursued upon the infected animal in the surroundings of an equipped laboratory. The work of these investigations will be reported by those who have actively participated in it, and the names of Stokes and Bauer are intimately linked to the first demonstration of successful transference of yellow fever to a highly susceptible animal and its subsequent retransfer to new animals both by inoculation and the mosquito (*Aedes aegypti*).

The immunity which has been demonstrated in the native African brown monkey and chimpanzee offers the suggestion that these animals have developed an acquired immunity through contact with the disease. However, further work must be carried out upon this subject to determine that this protection is not a natural species immunity. Although it has never been shown that there is any other host for the yellow fever virus than man and the mosquito, the demonstration of the susceptibility of the *Macacus rhesus* to the infection, makes it possible that the young native monkeys in the

endemic zones may acquire the disease and thus assist in its propagation. However, under natural conditions the home of the monkey is usually removed from the breeding places of the *Aedes aegypti* and it does not seem probable that this animal plays a material part in the endemicity of yellow fever.

In 1919 Noguchi isolated the *Leptospira icteroides* from the blood of patients, clinically diagnosed as yellow fever at Guayaquil, Ecuador. The number of instances in which the organism was recovered was small, and not a few cases gave negative results, even though a similar technique was employed and the disease was in its early stage. Sporadic isolation of similar organisms were later made in Mexico and in Brazil. Other investigators have been less fortunate, and have reported negative results, and up to the present time no one has been able to isolate any organism belonging to this group from yellow fever cases in West Africa.

It is of interest to note that Stimson in 1909 demonstrated spirochaetes (? leptospira) in the kidney of a fatal case clinically diagnosed as yellow fever. The Levaditi method has been used by us on the tissues of forty-seven human cases of yellow fever arising in America and Africa without a single positive result.

Sellards and his associates have recently made comparative studies on strains of *L. icteroides* and *L. icterohaemorrhagiae*. These organisms resemble each other closely in morphology, cultural characters, and in their pathogenicity for guinea pigs. Furthermore the pathological processes set up in the animal body are very similar for the two strains of organisms and no distinctive differentiation can be made. In neither instance do these experimental lesions resemble the peculiar characteristics of human yellow fever. It is of course to be remembered that there are many microörganisms pathogenic to man which may cause an intoxication and death in the experimental animal, and yet fail to produce the characteristics of the human disease. Both strains of the leptospira readily infect the guinea pigs, and give rise to an elevation of temperature, jaundice, haemorrhages and the presence of organisms in the kidneys and other tissues. The infection is usually fatal to the guinea pig.

In his studies on yellow fever in South America, Noguchi was able to obtain evidence of immune bodies in the circulation which reacted

with the *L. icteroides* and not or only slightly with the *L. icterohaemorrhagiae*. The most valuable of these immune reactions was the demonstration of positive Pfeiffer reactions using the blood of convalescent yellow fever patients and the *L. icteroides*. Similar positive results are also reported by Noguchi and Kligler, and Grovas, while Borges Vieira at Bahia in Brazil was unsuccessful both in isolating the leptospira from yellow fever cases, and in obtaining a positive Pfeiffer reaction on cases which had recovered. Similar negative reports are given by Aitken, Connal, Gray and Smith respecting the Pfeiffer reaction on the serum of a few yellow fever cases in West Africa. Sellards found that the *L. icteroides* and *L. icterohaemorrhagiae* behaved similarly towards the serum of convalescent yellow fever patients, both giving negative Pfeiffer reactions, while these two strains responded positively towards a known immune serum derived from an animal immunized against *L. icterohaemorrhagiae*. Recently Theiler and Sellards found that the serum from recovery cases of infectious jaundice gave positive Pfeiffer reactions with both the *L. icteroides* and *L. icterohaemorrhagiae*. From this they conclude that the two organisms are identical. Sellards points out that clinically, severe cases of infectious jaundice have many points in common with yellow fever and a differential diagnosis may be made with difficulty. Yet it is to be pointed out most emphatically that the organic lesions in the human as disclosed by careful pathological analyses are very distinct.

In a series of experiments to determine the question of mosquito transmission of the leptospira, Noguchi was able to transfer the infection from the human to one out of six guinea pigs used in the experiments. He was also able to transfer the virus from infected animals to two guinea pigs through the bite of nineteen and eighty-three mosquitoes respectively. He was also able to demonstrate the leptospira in the emulsion made from twenty-five mosquitoes of the latter group. Subsequently Gay and Sellards carried out another series of experiments to determine the fate of the *L. icteroides* and *L. icterohaemorrhagiae* in the mosquito (*Aedes aegypti*). Mosquitoes were allowed to feed upon infected guinea pigs and then at varying intervals of time were permitted to bite new non-immune pigs. In no instance were they able to transfer the disease from one animal to

another, although they were able to demonstrate the leptospira in the freshly ingested blood. By dark field examination of the stomach contents and of the mosquito tissues, actively motile leptospira were found during the first twenty-four hours but not later. On the other hand by grinding up batches of infected mosquitoes they were able to produce infection in guinea pigs as late as twenty-two days (but not later) after the infection of the mosquito by feeding. Finally too, they were unable to transmit infection by the leptospira by allowing the infected mosquito to bite human volunteers. This evidence would tend to show that not only does the leptospira diminish in numbers when taken into the body of the mosquito, but also that the mosquito is unable to transfer the organisms to susceptible hosts by biting. The cytolytic action of the mosquito stomach secretions and the destruction of ingested leptospira has been demonstrated by others (Kligler).

Inasmuch as the present day problem of yellow fever revolves about the situation as it exists on the West Coast of Africa, the conditions of the disease, the nature of the virus and the vectors must be studied in that region. There is little to fear from further serious outbreaks of yellow fever from former American endemic centers, since all of these are either completely wiped out, or under satisfactory control. The last center of yellow fever in America is in Brazil, and this has been quiescent for the last twelve months. The continued anti-stegomyia campaign in the suspected areas along with the general improvement of the sanitary conditions should do much to finally stamp it out.

The problem of the control of yellow fever in Africa is an entirely different one. The great extent of the West Coast serving as an endemic center stretches along a coast line of two thousand miles; the various colonies thus involved are unorganized to cope with such a problem; and little or no assistance can be expected through the efforts of the native people. Nevertheless the attack upon the yellow fever situation is not a hopeless one, for we are familiar with the procedure which has satisfactorily brought under control the epidemics in the Western Hemisphere, and has effectively wiped out the endemic centers. As the situation lies in the African territories it will be necessary to carry on a simultaneous crusade in a number of districts along the coast, and in particular in those colonies where the disease is

unquestionably endemic and recurrently epidemic. To clean up effectively one district alone, while the neighbouring provinces or colonies are infested with both virus and vector, would only be inviting an immediate recurrence at the end of the campaign. The work will require the closest coöperation of all the interested parties, and will demand a considerable force of men. However, all who have been associated with this problem of the eradication of yellow fever from various countries, are in sympathy with the hope and belief of Gorgas, that the disease can be eliminated from this earth. Gorgas did not live to see the progress that is being made in the study of yellow fever in Africa,—studies which we may hope will give us new weapons to continue the attack. The finding of a definitely susceptible animal gives an opportunity of uncovering many facts concerning the virus and the immunity conveyed by it, as well as information concerning its life cycle, and the most vulnerable point in it, where the progress of its dissemination may be interrupted. Until more information is available, the problem must remain in the laboratory, but within a short time it should be possible to change it to a practical problem in the field. The plans for approach must then be made to suit the situation in Africa, for it will not be possible to transfer the methods of organized communities in America, directly to the native districts of tropical Africa. A stegomyia survey has already been made in some districts on the West Coast, and enough data has been collected to show that this mosquito is an inhabitant of native villages and towns, not only along the coast but for considerable distances inland,—in places up to seven hundred miles and more. Wherever this mosquito finds a satisfactory habitat, the location becomes a potential menace for yellow fever, even though the disease up to that time has not visited the district. There are many such stegomyia areas in the interior of the West Coast which will needs be dealt with in a general anti-stegomyia campaign. As however, the *Aedes aegypti* are stated to cross the center of Africa to the East Coast, it will not be possible to follow this insect to all its haunts.

The demand for action in the yellow fever problem is becoming more insistent each year. Tropical Africa is taking its place in the world's economy, and the time is rapidly approaching when we will no longer view this continent as of secondary importance, but will look to it for

certain necessary supplies unavailable from other regions. The control of yellow fever will be a long step towards this realization.

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